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Tobacco Diseases in Kentucky

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RECOMMENDATIONS FOR CONTROL OF TOBACCO DISEASES IN KENTUCKY

Seed. Obtain seed of a satisfactory black-root-rot-resistant strain of tobacco, if possible, and plant no other kind until a better variety has been found. Two-year-old seed is perhaps preferable to one-year-old, for it is more likely to be free from the leaf-spot bacteria. Seed should not be saved from plants affected with ring-spot.

Plant Beds. Select a plant-bed site each year where tobacco has not been grown previously. A bed used year after year becomes infested with the black root-rot fungus unless burned or steamed thoroly or a highly resistant strain of tobacco has been grown. Beds should be located away from tobacco barns or other sources of tobacco trash. Burn or steam the bed very thoroly so that little weeding will be necessary. If horsenettles or groundcherries are found in the bed it is best not to handle them at all, either while weeding or pulling, because they sometimes carry mosaic. Never use ground tobacco stalks or other tobacco material, as it comes from the barn, on the bed as a fertilizer, because it is nearly certain to introduce mosaic. Commercial fertilizers are safe and are as effective as tobacco materials.* Boil old tobacco cotton unless it has been stored in a place free from tobacco trash. Have the cotton as insect-proof as possbile as there is a chance of the introduction of disease by insects. The importance of this has not been sufficiently demonstrated to warrant the added cost of boxing beds. When the tobacco plants are established in the bed, that is when the first leaves are just developing, spray or sprinkle the bed with 3-4-50 Bordeaux mixture at the rate of 1 quart per square yard. This tends to prevent the bacterial diseases angular leafspot and wildfire. Bordeaux mixture should not be expected to be effective if applied after these diseases have appeared.

Chewing and Smoking While Handling Plants. It has been clearly demonstrated in Kentucky that cured tobacco is the source of most of the mosaic infection of tobacco plants before and during transplanting. Therefore do not use natural leaf tobacco for either chewing or smoking and do not carry it or otherwise handle it while working around the plant bed. If natural leaf tobacco has been handled recently, scrub the hands thoroly with soap and water before handling plants in the bed. If natural leaf tobacco has been carried in the pockets, brush them out, after which plug or twist tobacco may be substituted. Commercial plug, twist, and scrap chewing tobacco

* See pages 8 and 9, Kentucky Extension Circular 77 (revised), for plantbed fertilizers.

usually are free from mosaic and are much safer to use than natural leaf tobacco. Pipe smokers should use some brand of canned smoking tobacco in preference to the natural leaf. Manufactured cigarettes probably are safe to use while working with the plants.

Field Practices. Do not set plants from a bed known to be affected with black root-rot unless the field soil is known to be distinctly acid. Soils high in organic matter, liberal applications of high-grade fertilizer, and liberal applications of manure all tend to reduce blackfire. The few mosaic plants found at the first cultivation should be hoed out, not pulled. If mosaic plants are encountered in Burley fields at topping time, leave them untopped and do not touch them when suckering. In dark tobacco fields the mosaic plants should be topped last. In wet seasons when rust of Burley tobacco is likely to be severe after topping, the last suckering should be delayed until cutting time and the tobacco cut immediately after suckering.

Horn-worms should be controlled by dusting rather than by hand worming. Handling the plants may spread mosaic.

Curing. To obtain well-cured leaf and to prevent houseburn, keep the relative humidity at about 85 percent until the leaves are dead and then gradually reduce it to 65 percent. Relative humidity above 90 percent is almost sure to result in houseburn if the tobacco is exposed to it for as long as twenty-four hours, especially at the higher temperatures within the range of curing.

BULLETIN NO. 328

Tobacco Diseases in Kentucky

W. D. VALLEAU and E. M. JOHNSON

The results of ten years study of tobacco diseases at the Kentucky Experiment Station are presented in this bulletin. The object of the study was to determine effective methods of disease control which may be adopted by the grower with the least possible change in established practices. It is recognized that it is not always an easy matter for the grower to become familiar with the details of each of the numerous diseases with which a crop may be affected, and with the methods of prevention recommended for each. For this reason a summary of recommendations for disease control has been prepared (see page 109) which, if closely followed, should be effective against diseases for which control methods are known, without requiring a detailed knowledge of any one of them. A more extensive discussion of the diseases, together with illustrations, is presented for those who are interested in a detailed study.

CAUSES OF TOBACCO DISEASES

Tobacco diseases may be considered as abnormalities of the plant which result in reducing quality or quantity of the commercial product. This definition includes malnutrition diseases of various types due to soil deficiencies, injuries caused by fungi, bacteria, round worms or nematodes, parasitic flowering plants as broomrape, virus diseases, and injury caused by burning of wilted plants. Insect injuries might be included, but will not be discussed in this Bulletin. A short description of the organisms causing disease may be of interest to those unacquainted with the lower forms of life.

The fungi are plants of a low order represented by mushrooms or toadstools and various molds which grow in damp places. A common fungus familiar to all is the green mold often seen on canned fruit. Certain forms of fungi are common causes of plant disease. They subsist either on the living plant cells, as rust of wheat and other cereals, and mildews of various crops, or by killing the plant cells and living on the dead tissues, as the fruit rots or black root-rot of tobacco.

Bacteria are sometimes classed as one of the groups of fungi. They are single-celled plants, the individual cells being visible only with a microscope. A mass of them, however, is readily visible to the unaided eye.

Virus diseases are caused by what are probably living organisms, so small that they cannot be seen with an ordinary microscope. Many plant and animal diseases are caused by viruses.

Nematodes are round worms which can sometimes be seen with the unaided eye. They are similar to the hookworm of the human and to round worms causing troubles in many animals.

Parasitic flowering plants are plants such as broomrape and mistletoe which have become adapted to obtaining food materials or nutrients directly from some other living plant instead of from the soil.

Physiological diseases, or those not due to disease-producing organisms, often result from a lack of sufficient available nutrients or an excess of one or more of the compounds necessary for plant growth. The quantity of available nutrients in the soil may be influenced by changing soil conditions, such as temperature and moisture, as well as by the total quantity present in the soil. If it is kept in mind that diseases may be produced by any one or a combination of causes, it will be easier to understand the reason for the various control measures recommended and the changes which are made from time to time in these recommendations as new facts are discovered.

SOIL IN RELATION TO TOBACCO DISEASES

Growers are well aware of the desirability of selecting the most favorable soil for tobacco. The reasons for the selection or rejection of certain soils for tobacco are not always well understood but are usually arrived at by experience. The relation of soil to diseases will be discussed more fully under the specific diseases but reference is made here to a few of the more obvious relations.

Soil Fertility. A proper balance of the necessary nutrients must be maintained in the soil throughout the growth period of the tobacco plant, to obtain normal development. Lack of sufficient quantities of certain compounds may result in leaf spots and various other types of deficiency or malnutrition diseases, or in slow growth and late maturity of the crop.

Soil Reaction. Soil reaction or the degree of its acidity or alkalinity appears to be an important factor. Experience has demonstrated that tobacco thrives best in a slightly acid soil. The use of too much lime tends to increase black root-rot and quite often seems to be a contributing cause of frenching. In strongly acid soil toxic materials are liberated which, when taken into the plant, result in slow growth and leaf spotting. On such soil a light application of lime may prove beneficial to tobacco.*

Organic Matter. Organic matter, if well rotted and mixed with the soil, is generally beneficial to tobacco because it tends to increase fertility and to reduce leaf-spot diseases. Manure is generally beneficial to both White Burley and dark tobacco, but if successive crops of tobacco are grown in manured soil, black root-rot is almost certain to develop. Plant debris, such as leaf mould, when turned under in newly cleared land, sometimes causes tobacco to french if it is the first crop.

Crop Rotation. The tobacco grower should give careful study and should profit by past experience in selecting land for tobacco. Tobacco often grows slowly following corn, soybeans, alfalfa or timothy; whereas the crop appears to be benefited if

* For recommendations on fertilizing tobacco soils, see Kentucky Experiment Station Bulletin 322, pages 414 to 416, and for recommendations on liming see pages 411 and 412.

it follows red clover, bluegrass, orchard grass, lespedeza or a heavy stand of weeds. A large amount of organic matter such as a heavy sod or weed growth turned under usually is beneficial to tobacco. However, where heavily pastured sods are turned under, tobacco not properly fertilized often grows slowly and makes leaf of poor quality.

Physical Condition of Soil. Good physical condition of the soil is necessary, especially good surface and under drainage. Tobacco often frenches on soil which is too wet, or if water stands long about the plants it may cause them to wilt, turn yellow, and finally die. On hard, poorly aerated soil tobacco grows slowly and produces inferior leaf. Loose, open soil is likely to result in rapidly-growing, high-quality tobacco, if the necessary nutrients are available.

PHYSIOLOGICAL DISEASES

Physiological diseases may be brought about by a temporary or permanent lack of certain elements in the soil. Nitrogen, phosphorus and potassium are the three elements most likely to be deficient in Kentucky soils. Magnesium deficiency, which causes sand drown, and calcium deficiency, which causes irregularly shaped leaves, rarely, if ever, occur. The object of the tobacco grower is to mature large, well-formed leaves of high quality. This development is largely dependent on proper nourishment of the plant. Therefore much attention should be paid to soil improvement and to the kind and amount of fertilizer used.

Nitrogen Deficiency. A deficiency of nitrogen is indicated by slow-growing, light-green plants. Yellowing of the lower leaves during dry periods often is caused by the inability of plants to obtain nitrogen and is a common example of nitrogen starvation. An abundance of available nitrogen in the soil, if other necessary elements and moisture are present, produces rapidly growing, vigorous, dark-green plants, except in periods of excessive heat, when the lower leaves may yellow.

Prevention. Liberal applications of manure or of fertilizing materials high in nitrogen prevent nitrogen starvation.

Phosphorus Deficiency. This is indicated by slow-growing, stunted, dark green plants. This condition cannot be recognized readily unless plants well supplied with phosphorus are growing nearby for comparison. A lack of available phosphorus appears to be a common cause of slow growth and late maturity of tobacco in most parts of Kentucky, outside of the Central Bluegrass area. In the greenhouse phosphorus-starved plants frequently develop water-soaked areas in the leaves, but it is not known what part the deficiency may play in the production of leaf-spots in the field and after the tobacco is harvested.

Prevention. Phosphorus starvation is prevented by the use of phosphate fertilizers or liberal applications of mixed fertilizers high in phosphorus. Manure is low in phosphorus and cannot be relied upon to correct phosphorus deficiency.

Potash Deficiency. Altho Kentucky soils generally are quite high in potash, tobacco frequently shows signs of potash starvation. This is because the rate at which potash becomes available in the soil is not great enough to meet the needs of the tobacco crop, which requires a large amount in a short time. Potash starvation is readily recognized in tobacco. The leaves are curled downward at the edges or are "rimbound". The portions of the blade of the leaf between the larger veins are curved upward as though the veins were too short. The leaf usually is light green with yellowish blotches, and the whole plant may have a distinct bronze tinge.

Prevention. Potash starvation may be prevented by applying barnyard manure, potash fertilizers, or liberal quantities of mixed fertilizers which contain a high percentage of potash. In sandy soils of the southeastern part of the United States too large an application of potassium chloride (muriate of potash) causes tobacco leaves to thicken and curl upward. Cured tobacco containing too much chlorine is of inferior quality, as it holds water and consequently has a poor burn. This difficulty has not been encountered in Kentucky except where excessive quantities of potassium chloride have been used experimentally.

Frenching. Frenching, or wet weather french, tho sometimes confused with the mosaic disease of tobacco, is a distinct

disease. Newly frenched plants are nearly white in the growing point (figure 1). The frenched leaves are narrowed and drawn and the tips sometimes bend sharply downward forming

Figure 1. Frenching of White Burley tobacco which developed soon after the plant was set.

a cup of the underside of the leaf. Later, affected leaves may turn dark green. In severe cases the leaves may be reduced to narrow straps made up mostly of the midvein, and the number of leaves is greatly increased, sometimes to hundreds on a plant. Frenching develops under a variety of conditions. It is more prevalent in seasons of abundant rainfall and nearly absent

during protracted dry periods. Frequently it develops in plants in rich soil with an abundant water supply. It may occur in soil that has been limed, whereas plants growing in similarly treated but unlimed soil, may be free from it. It appears that liming is more likely to induce frenching in soil of low rather than of high organic matter content. Frenching occurs in soil which is near the neutral point (about pH 6 or above*) but it is probable that plants growing in soil of the most desirable acidity for tobacco (about pH 5.6) will not french.

Studies of the disease in the greenhouse have shown that sometimes it is associated with a lack of available nitrogen in the soil, but at other times it seems to occur in the presence of available nitrogen when other nutrients are deficient. The frenched condition appears to result from a lack of balance, within the plant, perhaps between the rate of development of new leaves (carbohydrate translocation) and the rate of translocation of nitrogenous compounds to these leaves, the latter seeming to be retarded. If this is true, then a deficiency of other elements than nitrogen, which go into the makeup of these compounds, may induce it. The frequent occurrence of frenching in newly cleared forest land, seems to be due to an inadequate supply of nitrogen.

Prevention. Frenching can always be prevented in the greenhouse by sufficient applications of the necessary fertilizing elements. Under field conditions prevention is not so simple because of the variety of conditions under which the disease occurs. The addition of readily decayable organic matter, proper soil drainage, and the application of fertilizers recommended for tobacco, probably will prove effective in preventing frenching in soil known to produce the disease. If lime is to be used on tobacco land apply a small quantity following the tobacco crop rather than immediately preceding it.

* The term pH refers to acidity or alkalinity of the soil. A neutral soil has a pH of 7. Figures smaller than 7 indicate degree of acidity; figures larger than 7, degree of alkalinity. The soils of the Bluegrass Region are about pH 5.6; most of those of the rest of the state are more acid.

PLANT-BED DISEASES

Under this heading only those diseases that are confined to the plant bed are discussed. Angular leaf-spot, wildfire, mosaic, and black root-rot all affect plants in the bed but will be discussed under their respective headings.

Blackleg. This disease occurs in the plant bed during wet periods when the plants are about ready to set. It is a bacterial soft rot attacking the leaves which touch the ground and spreading from them into the soft, tender stalk. This may rot off completely, or if the stalk has become somewhat hard, the rot may spread up one side, splitting it open. The rotted areas usually turn black, hence the name (figure 2). Frequently all the plants in a circle a foot to three feet in diameter are destroyed. Slightly affected plants when set in the field grow normally. The disease is caused by one (*Bacillus aroideae*) of the group of soft-rot bacteria which have been shown to be carried by certain insects. The method of entrance into the bed

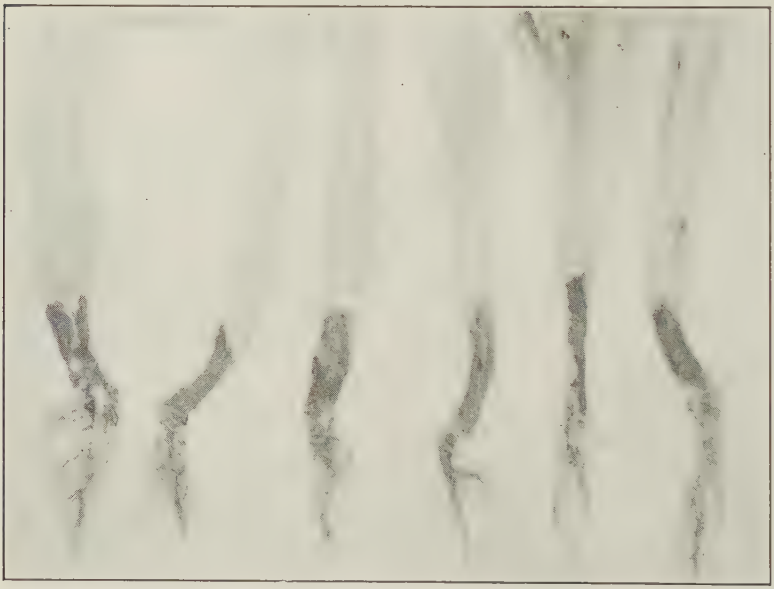


Figure 2. Blackleg of White Burley tobacco. The disease occurs in the plant bed as a soft rot, when the plants are about ready to set.

is not known and measures for prevention cannot be recommended other than that of removing the canvas and drying and hardening the plants when the disease is first noticed.

Figure 3. Cold injury to a White Burley tobacco plant in the plant bed, following a cold, windy night. The plant was transplanted for photographing. It recovered quickly when placed in the greenhouse. The same type of injury occurs on dark tobacco.

Cold Injury. This (figure 3) often appears on individual plants in the bed which are exposed by a tear in the canvas or by other means. In the springs of 1929 and 1931 cold injury was prevalent in plant beds, often affecting a majority of the plants. It occurred both years following cold, windy weather. The bud leaves turn white and the partially developt leaves appear constricted and white along the edges of the distal portion. Affected plants recover quickly and grow normally, following a rise in temperature, except that the affected leaves may remain mottled, having somewhat the appearance of a mild mosaic.

ROOT DISEASES

Black Root-Rot. The black root-rot organism* attacks the tobacco roots either in the plant bed or the field, rotting them and eventually turning them black (figure 4). It may be par-

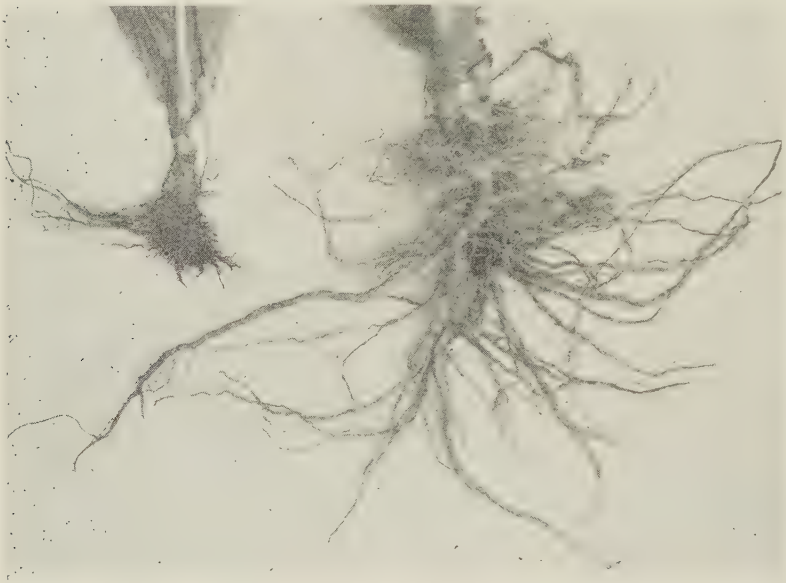


Figure 4. Black root-rot of White Burley tobacco. A healthy root of a root-rot-resistant strain and the root of a susceptible variety grown in the next row. The short, stubby, black roots, with a few normal roots near the surface of the ground, are characteristic of a severe case of this disease.

ticularly severe where tobacco is grown repeatedly in the same soil, or in plant beds where the same site is used several times without thoro sterilization. Injury in the bed may be so slight that diagnosis is difficult. In severe infestations the disease is recognized by slow growth of the plants and yellowing of leaves where there is no moisture deficiency, and by the presence of dead, blackened roots. In the Bluegrass section, the disease often is present in burned plant beds which are used a second time. It is often present in plant beds in Daviess County where

* This disease is caused by the fungus, *Thielaviopsis basicola.*

the custom is to manure and use the same plant beds year after year. Satisfactory plants usually are grown in these beds because steaming sterilizes the soil to a sufficient depth to permit the plants to develop. However, many of the roots penetrate the infested layer of soil and the disease may thus be carried to the field. The common practice of using a new plant-bed site each year, is a good protection against black root-rot. Steaming permanent plant beds only sufficiently to control weeds, has not proved effective in freeing them from black root-rot. Unless steaming is thoro it should not be relied upon to sterilize infested soil. It is particularly necessary to change the plant-bed site frequently when the plants are to be set on limed soil or soil of low acidity, as in the central Bluegrass. All the named varieties of White Burley and dark tobacco tested have proved highly susceptible to the disease in infested plant beds and nearly all of them are badly injured if set in infested fields.

Black root-rot is often responsible for slow growth of tobacco in soil known to be in a high state of fertility, especially when liberal applications of manure have been made (figure 5). In the Bluegrass section, if the fungus is carried from the plant bed to the field, it usually remains in the field indefinitely, causing some injury to each succeeding crop. In the more acid soils of western Kentucky this organism does not become established so readily unless the land has been manured or limed and the organic matter content built up. On some of these acid soils infected plants from a diseased bed make as good growth as highly resistant plants of equal quality from the same bed. Where lime is to be used on tobacco land it should be applied following tobacco and in as small a quantity as will give the desired effect in growing legumes.

If black root-rot is present in the field, a resistant strain of tobacco should be used. Moderately resistant strains of White Burley are now widely distributed in the State and are being grown extensively (figure 5). They have not proved resistant under the low temperature existing in the plant bed and are not always resistant when set in the field, especially if set early or if the season is particularly cool (figure 6). They have, how-

Figure 5. Susceptible and root-rot-resistant White Burley tobacco. The field pictured was not known by the grower to be infested with black root-rot. A common variety (left) and a resistant selection (right) were grown side by side in several parts of the field, with results in each case similar to those shown above.

Figure 6. Breeding White Burley tobacco for resistance to black root-rot. Center is strain M, a selection from a White Burley variety. Most seasons it is resistant (see figure 5) but in 1930 (above) it was set three weeks earlier than usual. Under the lower temperature it proved susceptible. Left, Burley 1; right, Burley 5, strains produced by cross-breeding, which proved resistant under the same conditions. These two strains are of high quality. Number 5 is now being grown commercially in Kentucky.

ever, proved valuable in many infested fields. More highly resistant strains of White Burley have been developt by the Kentucky Experiment Station (figure 6) and during the past two

years have been tested thruout the Burley district with satisfactory results. Highly resistant strains of dark tobacco have been developt, but require further improvement before introduction. Eventually all tobacco grown in Kentucky should be of a resistant type.

Prevention and control. To avoid injury in the plant bed use a new site each year or steam a previously used bed at least 30 minutes, preferably 40. To prevent infestation of a field do not use plants from a diseased bed unless the field soil is very acid. If lime has been used on the tobacco land, use a new bed each year. Manure increases injury from black root-rot so that tobacco should not be grown in successive years on heavily manured land. Use a black-root-rot-resistant variety of tobacco, if a satisfactory one can be obtained, whether the soil is infested or not, as it will reduce injury in an infested soil and prevent a clean soil from becoming infested.

*Brown root-rot** is a rot of the rootlets of tobacco plants in the field, but has not been observed to cause much injury in plant beds. The disease appears to be worse in soil of low available fertility. It may be present but appears to cause little injury in highly fertile soil. If the plants are severely attacked soon after setting, most of the rootlets are rotted back to the taproot, stunting the plant for the greater part of the season (figures 7, 8). Recovery may come about thru development of roots from the crown and a fair crop may be produced. If infection is not severe, the plants may grow normally except that they wilt on hot days. If the roots of such plants are examined at any time during the growing season, numerous rotted rootlets will be found. Certain varieties show slightly greater resistance, as indicated by less wilting, than others, but the difference is slight when the disease is severe and at present the development of resistant strains does not seem to offer promise as a means of control. If the susceptible White Burley varieties (those wilting the most) have made fairly normal growth, they often make a

* The exact cause of the disease is not known, but in Kentucky it appears to be a Pythium, probably the same one which causes root-rot of corn in this and other states. A Pythium is isolated readily from the rotting tobacco rootlets.

better quality of leaf than the slightly more resistant varieties. The disease has been severe after corn, alfalfa, soybeans, and timothy on the Experiment Station farm at Lexington and, if this occurs elsewhere, the rotation should be arranged so that tobacco does not follow these crops. The disease does not appear to become worse with frequent cropping to tobacco; a tobacco crop following a diseased one may be nearly free from the disease. Brown root-rot apparently does not affect tobacco seriously following a good bluegrass sod, lespedeza, red clover, or a heavy growth of weeds. While some investigators believe that turning under organic matter may cause brown root-rot, experience in Kentucky indicates that the more of certain kinds of organic matter turned under, such as blugrass sod or weeds, the less chance there is of brown root-rot being in evidence. The disease may be particularly severe following heavily pastured sods.

Prevention. By employing certain crop rotations, keeping the soil well supplied with organic matter and applying liberal

Figure 7. A portion of a field of White Burley tobacco affected with brown root-rot. The field had been in corn for the previous ten years thus indicating a crop relation between the root disease of corn and of tobacco. Photographed September 2, 1923.

amounts of commercial fertilizers, injury from brown root-rot should not be serious. It appears advisable to use the fertilizers in the row or hill to as great an extent as is possible without injury from them.

Figure 8. Brown root-rot of White Burley tobacco from the field shown in Figure 7. Nearly the entire active root system has developt near the soil surface.

Root Knot. This is caused by nematodes, or round worms. It is found occasionally in tobacco plantings in Kentucky. The disease probably occurs most commonly on tobacco growing on land previously used for a garden. Nematodes are frequently introduced into garden soils on tomato plants grown in the greenhouse or shipped from the South. The tobacco roots and rootlets are enlarged at irregular intervals, giving them a more or less beaded appearance. If the knots are broken open carefully, the small, white, spherical, female worm may be found sometimes in the center of the knot.

Control. Root knot is not serious in this State and requires no special precautionary measures, but in the rare event that it

does become serious it can be eradicated by growing a weed-free crop of corn or wheat or some other grass for two or more years.

Club-root. This is a rather rare disease of tobacco. The first leaves of an affected plant are normal but succeeding leaves

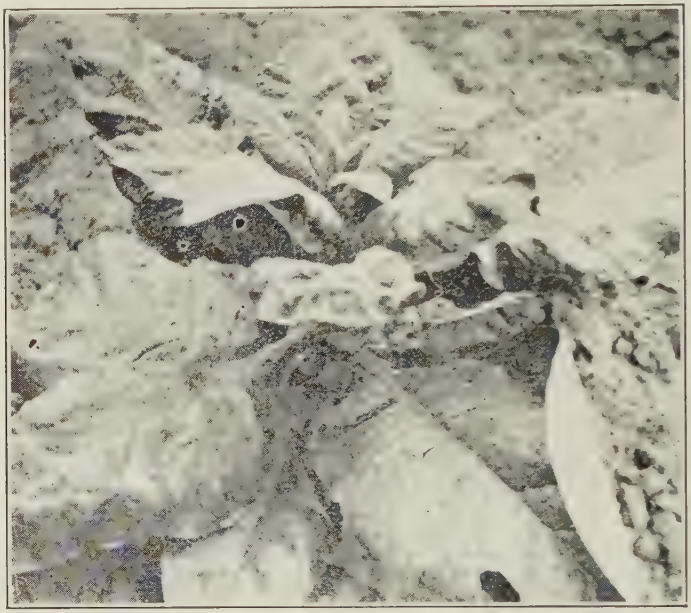


Figure 9. A plant of cigar tobacco showing the type of growth typical of club-root. Photo by F. D. Fromme, Germantown, Ohio, August, 1927.

are progressively shorter. This, with the shortened stalk, gives the plant a squat, pyramidal appearance (figure 9). The leaves appear rigid and stand out nearly at right angles to the stalk. The internodes of the flower stalks are short. The roots of such plants are always enlarged having the general appearance of cabbage roots affected with club-root disease* (figure 10).

The first specimens of plants affected with club-root were received by the writer from County Agent H. F. Link, Alexandria, Campbell County, in August, 1922. The disease has

* The disease is not caused by nematodes, as a thoro search failed to reveal their presence. These findings were confirmed by Dr. N. A. Cobb, of the Bureau of Plant Industry, Washington, to whom specimens were sent on two occasions.

Figure 10. Club-root of tobacco. Nothing is known as to the cause of this rather rare disease. While it has much the appearance of root-knot, nematodes are not found in the roots. Specimens from Campbell County, August 16, 1922.

also been found affecting both White Burley and air cured dark tobacco on a farm near Owensboro, Kentucky, and has been found in Fayette County. The cause of the disease is not known, and little is known as to its occurrence in Kentucky. Undoubtedly it has been confused with nematode injury in the past. Considering the long time that tobacco has been grown in Kentucky and the rare occurrence of the disease, it is not likely to become serious.

Broomrape. This is a parasitic flowering plant (*Orobanche ramosa*) which grows upon the roots of tobacco, hemp and other plants (figure 11). It is incapable of forming green coloring matter, and therefore cannot elaborate its own food materials but takes them directly from the roots of the plant upon which it lives. It produces seeds in abundance which are capable of remaining in the soil for many years in a viable condition; con-

Figure 11. A plant of broomrape *(O. ludoviciana)* on a tobacco root. This parasitic flowering plant may cause extreme injury to a field of tobacco. (Photo by H. Garman, Kentucky Bulletin 105, Fig. 14.)

sequently broomrape may appear in fields which have not been planted to either tobacco or hemp for a very long time. The parasitized tobacco plants take on a sickly, yellowish, starved

appearance, at which time large masses of the broomrape can be seen around the base of the tobacco plant. The broomrape, which is very injurious to tobacco in the Bluegrass section of Kentucky, is supposed to have been introduced with hemp seed when hemp was widely grown in that part of the State.

Prevention. No way is known to prevent broomrape in fields known to be infested. Avoid planting tobacco in them. In a mild infestation it would probably be well to pull the broomrape plants from the roots of tobacco before the broomrape seeds develop. This would prevent further soil infestation, and benefit the tobacco.

LEAF DISEASES

Angular Leaf-Spot. This bacterial disease* sometimes called rust in the White Burley section, is widespread in Kentucky and in certain years is the cause of considerable injury to tobacco. The disease appears in the plant bed rather suddenly, on tender, rapidly growing plants, as water-soaked spots on the under side of the leaves. These spots rapidly turn brown, giving the plants a scorched appearance. Following a severe outbreak, the plants usually recover rapidly and may show but few signs of infection at setting time, the earlier affected leaves having died. The spots on older leaves are recognized by the presence of small, irregular, nearly black centers, surrounded by a narrow halo or band of yellow (figure 12, A). With age the centers may turn nearly white. The tissues around the spot, especially on plants in the bed and on rapidly growing tobacco in the field, are often puckered and torn. The disease is generally present in White Burley plant beds, sometimes resulting in considerable injury if the plants are small. Dark tobacco appears to be more resistant to the disease. It is difficult to find angular leaf-spot on dark tobacco plants even when they are growing in the same bed with heavily infected White Burley plants. The disease is carried to the field on young plants where it may spread rapidly, during rainy, windy weather. The spotting of White Burley tobacco which occurs

* Caused by the organism, *Bacterium angulatum.*

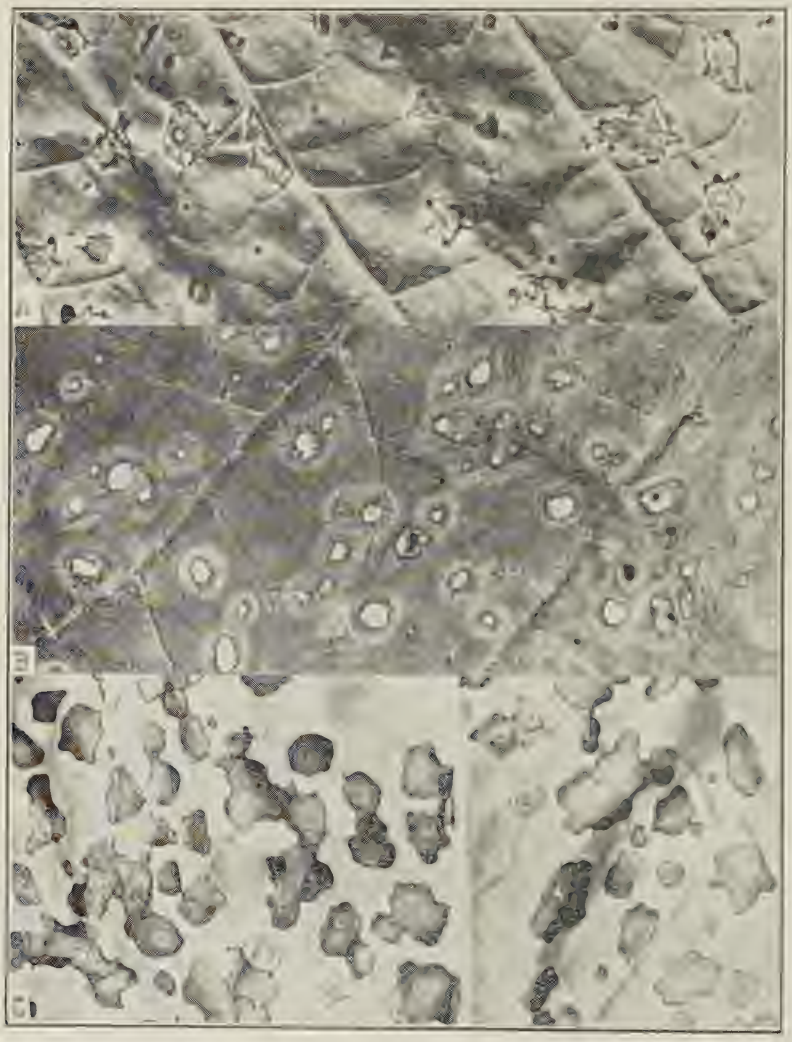


Figure 12. Three leaf-spot diseases of tobacco. A. Angular leaf-spot B. Wildfire. These are two bacterial diseases which are sometimes destructive to tobacco. C. Rust, or blackfire, as it occurs on White Burley tobacco. This appears to be the disease which is so evident during wet periods after topping and suckering and is a destructive disease of dark tobacco.

in wet seasons, especially following the last suckering, and the disease of black tobacco commonly called blackfire by the growers in western Kentucky result from physiological breakdown and are not due to the angular leaf-spot organism. This type of spot is discussed under the heading "Blackfire and Rust."

All the ways in which the angular leaf-spot organism overwinters are not known. Sometimes the bacteria appear to overwinter in the seed and can certainly overwinter in tobacco trash in the barn, but these sources do not seem to explain all cases of plant-bed infection. There may be a source of infection entirely unrelated to previous tobacco crops. Three years in succession beds on the Experiment Station farm sowed with seed raised in the greenhouse, and therefore thought to be entirely free from infection, and handled with every precaution to prevent accidental infection, were found to be extensively infected before pulling time. In 1929 the bed was extensively infected with wildfire also. The beds were plowed out of bluegrass sod, and so located as to be away from any danger of contamination from previous crops, other than wind-blown material. Experience seems to indicate that the bacteria which cause angular leafspot are practically always present in White Burley tobacco plant beds everywhere in Kentucky and to a less extent in dark tobacco beds. The beds may remain apparently free from visible signs of infection until the plants are well developed and then, in the course of two or three days, the disease may break out in all parts of the bed in a severe form. The conditions which bring about these sudden outbreaks and the source of the bacteria which cause them are not well understood.

While it is generally believed that field infection always originates in the plant bed, this has not been clearly demonstrated; consequently control of the disease in the bed may not prevent field infection. Plants from the 1931 beds, on the Experiment Station farm, not visibly affected with angular leafspot at setting time, soon developed infection after setting in the field.

Prevention. In view of our limited knowledge of both angular leaf-spot and wildfire, no recommendations can be made

which can assure prevention of infection in the plant bed. Measures which may be of value in reducing plant-bed infection are: The use of two-year-old seed, as it appears to be free from infection; the use of new or boiled canvas or of canvas which has been stored away from all tobacco trash; locating the plant bed so that tobacco trash from the barn will not be washed, blown, or carried into the bed, and abstaining from carrying natural-leaf cured tobacco to the plant bed in the pockets.*

Wildfire is a term used erroneously by tobacco growers to mean any leaf disease which spreads rapidly thru the field. Properly it should be used to designate the bacterial leaf-spot disease† characterized by the development of lemon-yellow spots on the leaf (figure 12, B), usually about 3/8 of an inch in diameter. These spots are so characteristic they can readily be distinguished from any other disease in the plant bed or when spreading rapidly in the field. A small dead area develops in the center of the yellow spot and other dead areas may develop near the margin of the yellow area. The disease when present may be destructive but has rarely occurred, in the past 9 years, anywhere in Kentucky. It has been found three times in Calloway County but no record has been made of it in any other part of the dark tobacco section of Kentucky. Probably the bacteria

* In studies on the control of angular leafspot conducted previous to 1932, the main efforts were directed toward preventing infection of plant beds by the use of clean seed, seed treatments, and sanitary measures of various kinds. These measures proved ineffective in preventing the diseases, altho certain of them may have been beneficial at times. In 1932 a study was started to determine, if possible, when plantbed infection occurs. Bordeaux mixture, which has been found to be effective in the control of wildfire in regions where it commonly occurs, was to be used on the plants at different times, in the hope that the time might be determined at which infection occurred. This test indicated that a single drenching with 2-3-40 Bordeaux mixture, at the rate of 1 quart per square yard, applied when the first true leaves were just developing, was effective in protecting the plants thruout the plantbed season. In the undrenched portion of the bed, the plants became severely infected.

Bordeaux mixture is cheap and is easy to apply with a sprinkling can. It should be applied while the plants are small and before the disease appears. Bordeaux mixture suitable for sprinkling on tobacco plant beds is prepared as follows: 50 gallons, sufficient for 66 yards of bed 9 feet wide, require 4 pounds of chemical hydrated lime, 3 pounds of finely powdered copper sulfate (bluestone), and 50 gallons of water. Dissolve the bluestone in a bucket of water. Mix the lime into a thin paste with water in another bucket, and pour it into the water in a barrel or other container, containing about 46 gallons of water. Then, while stirring vigorously, pour in the copper sulfate solution. The Bordeaux may be prepared in a wooden barrel, or 60-gallon oil barrel, and may be applied to the bed with an ordinary sprinkling can. It is best to wash out the containers before use, so that the sprinkler will not become clogged. The mixture should be stirred every time a portion is removed from the barrel.

† Caused by *Bacterium tabacum*.

are sometimes carried over winter in tobacco seed, altho we have no evidence to this effect. They are certainly carried over in tobacco trash. But the disease occurs in plant beds under circumstances where infected seed and tobacco trash, unless windblown, could not have been the source. Both wildfire and angular leaf-spot have been introduced, experimentally, into plant beds by chewing natural leaf tobacco of the previous crop which was known to be affected, and spitting on the plants. There is evidence that the disease may appear in the field without having first been present in the plant bed.

In view of the rare appearance of the disease in Kentucky, preventive measures, unless very simple and inexpensive, are not warranted. The recommendations for prevention of angular leaf-spot should be equally effective for wildfire. Bordeaux mixture, 3-4-50, if applied as a drench at the rate of one quart to the square yard, before the disease appears, has been found to prevent the disease in regions where it is commonly present in plant beds.

Blackfire and rust are terms used by growers in referring to the spotting of White Burley and dark tobacco, as it occurs late in the season. Any burned condition of the leaves is also called rust. While the terms, angular leaf-spot and blackfire, are used interchangeably in some of the literature, it seems preferable to retain the name blackfire for the late-season disease of dark tobacco, as the growers have referred to the disease by this name for many years, and use angular leaf-spot as the name of the bacterial disease. Blackfire is undoubtedly the most destructive leaf-spot disease in western Kentucky during wet seasons and is the so-called rust of White Burley which is very destructive in wet seasons, following topping and suckering. At one time the spots were considered to be caused by the angular leaf-spot organism, but more recent evidence suggests that they are due to faulty nutrition, not to bacteria. Spotting is more prevalent in low, wet places and in eroded areas, and is usually nearly absent in fields of high productivity, especially when the physical condition of the soil is favorable. The spots begin as water-soaked areas which appear over night. They

increase in size leaving a target effect as the newly killed tissues dry (figure 12, C). This spot is reported by growers to spread after the tobacco is housed, which appears never to be the case with angular leaf-spot and wildfire. Water-soaked spots have appeared over night on leaves from plants grown in an affected field, and kept in the laboratory with the base of the leaf in water. What appears to be the same kind of spot sometimes begins on the lower side of leaves which have been turned over by wind during a rain storm. Examination has generally shown them to be free from bacteria. In the dark-tobacco sections striking instances of freedom from blackfire have been observed where heavy applications of stable manure have been used or where organic matter from other sources has been introduced into the soil. Likewise manure appears to have a beneficial effect in reducing this disease on White Burley tobacco. Treatment with a liberal application of a fertilizer containing nitrogen, phosphorus and potassium has had a marked effect in reducing the disease in rotations on certain of the soil experiment fields. Methods of handling the White Burley crop appear to influence the severity of the disease. Plants topped low and kept closely suckered may be susceptible to injury, whereas plants left untopped, or topped and one or two suckers allowed to develop, may remain free from spotting until topped or suckered. If the tops or suckers are removed during a rainy period, the tobacco may be damaged extensively in two or three days. A prevalent belief of tobacco growers is that as long as tobacco is making good, uniform growth it is not subject to this type of leaf spotting. As a result of experiences of this kind some Burley growers have adopted the practice of not topping the tobacco until cutting time, and others top but allow one or two suckers to develop in the top of the plant until cutting time. The plants are then suckered and cut immediately. While the exact nature of the disease is not fully understood it appears to develop under conditions which stimulate rapid translocation of food material from one part of the plant to another, such as occurs when the growing points are removed in the operation of suckering.

Prevention. As the disease appears to result from faulty nutrition, prevention will probably depend on a soil-building program including the use of legumes, and on liberal use of mixed fertilizers.*

Frogeye. Frogeye, which is caused by a fungus,† is common in Kentucky but is rarely the cause of serious injury to tobacco. The spots are found on the lower leaves in damp locations. They have a dead, white, parchment-like area in the center, about 3/16 of an inch in diameter. In this area is an indistinct grayish mass of spores (figure 13). The tissue surrounding the

Figure 13. Frog-eye of White Burley tobacco. The parchment-white spots with the gray centers are typical of this disease.

spot is a light orange yellow blending into the normal green of the leaf. As the yellow area sometimes becomes quite wide, the spots might be confused with wildfire. The disease is not very injurious and little has been done to discover its life history. No means of prevention are known.

Leaf scald. Every year scalding of White Burley tobacco leaves may be observed. In 1930 it was prevalent in early,

* For recommendations on the fertilization of tobacco see Kentucky Experiment Station Bulletin 322, pages 414 to 416, and Extension Division Circular 230, pages 5 to 9.

† This disease is caused by the fungus, *Cercospora nicotiana.*

rapidly growing tobacco which had attained considerable size before the drouth became severe. The scalding, which usually occurs on about two leaves of a plant, develops while the leaves are badly wilted. The parts of the wilted leaf folded together and exposed to brilliant sunlight fail to recover, turn a bluish-green color and later dry and turn brown (figure 14, A, B). In 1930 the chief cause of wilting appeared to be a lack of water.

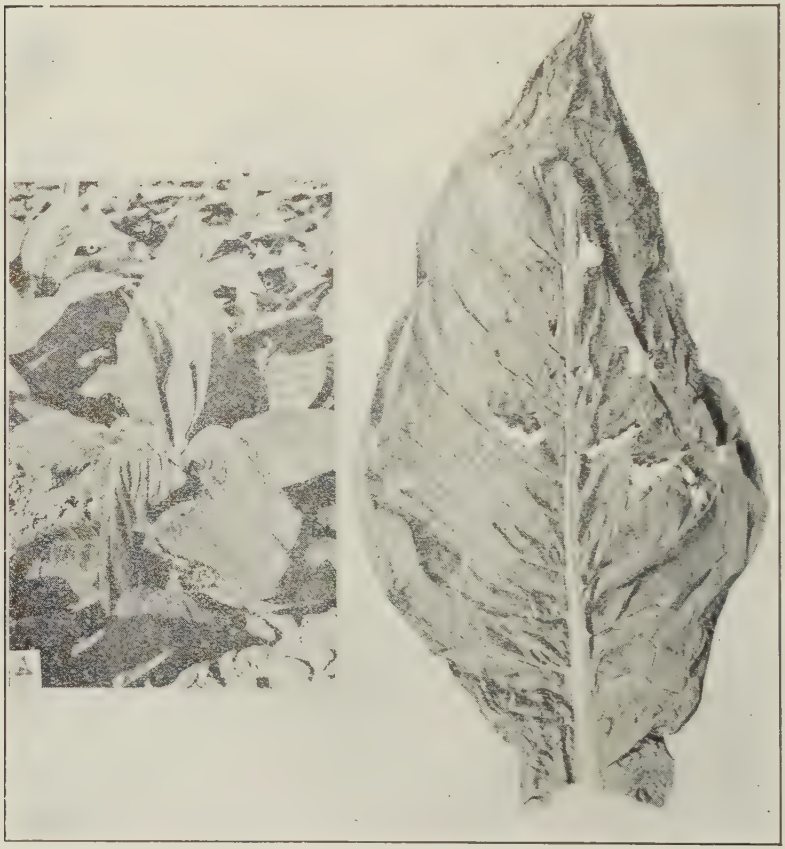


Figure 14. Leaf scald of White Burley tobacco. A. Two leaves badly wilted. Wilting of this kind is usually attributed to the sting of an insect. B. A leaf such as is shown in A following recovery from wilting. Some parts of the leaf were so badly wilted that death followed. The dead areas are at first bluish green and later turn brown.

According to observations of growers wilting is sometimes caused by the sting of one of the stink-bugs. No preventive measures are known.

VIRUS DISEASES

Mosaic. There are many virus diseases of tobacco; the most destructive of them is tobacco mosaic (figure 15). This disease is present wherever tobacco is grown. It is known to most tobacco growers, altho often by some other name than mosaic. In some parts of Western Kentucky it is called walloon; in other parts of the State, black french, dry weather french, frenching, etc. The disease is characterized by a mosaic pattern of light and dark green areas in the leaf. An important effect of the disease, which is seldom associated with it by the grower, is mosaic burning (figure 16). This is a spotting or burning of large areas which are most exposed to brilliant light. The burning begins as numerous small specks which gradually increase in size and result finally in the death of a large area. This form of the disease is particularly prevalent during dry, hot weather. The burning seems to occur only in leaves which are immature when infection occurs. Older leaves show no symptoms, whereas younger leaves and suckers become mottled. When burning occurs following topping it is evidence of infection at topping time.

There are several distinct strains of the mosaic virus which differ in the color and patterns induced. Certain ones cause severe distortion, others practically none (figure 15); one causes the plants to turn nearly white, and another causes them to become blotched with yellow (figure 19, D). From a practical standpoint they may all be considered as one disease. The cause of the disease appears to be a living organism called a virus, too small to be seen with a microscope, but readily transferred from diseased to healthy plants by handling one and then the other. The virus of the disease has been shown to remain alive for 30 years in cured tobacco and in one test it appeared to be present in a sample of tobacco reported to be 54 years old. Thus it is practically always present in the natural leaf chewing or smoking tobacco used by tobacco growers. As the disease is

readily transferred from dried tobacco to living plants, the tobacco grower himself is often the chief agent in introducing the disease into the plant bed or field. It has been clearly demon-

Figure 15. Mosaic of tobacco. There are several distinct strains of the typical tobacco mosaic which differ in severity of the symptoms produced on the plant and in the color produced in the affected leaves. Usually the affected leaves are various shades of green but one strain produces yellow blotches while another turns parts of the leaf almost white. A mild and severe form of mosaic are shown here.

strated that a man who uses natural leaf tobacco contaminated with the virus, either for chewing or smoking, may transmit the disease readily to healthy plants while pulling. Once introduced, the disease is easily spread during operations in which the plants are handled, such as pulling, topping, and suckering. In a field where the disease has been prevalent earlier, many of the suckers are likely to be diseased following cutting. The virus does not appear to be carried in tobacco seed.

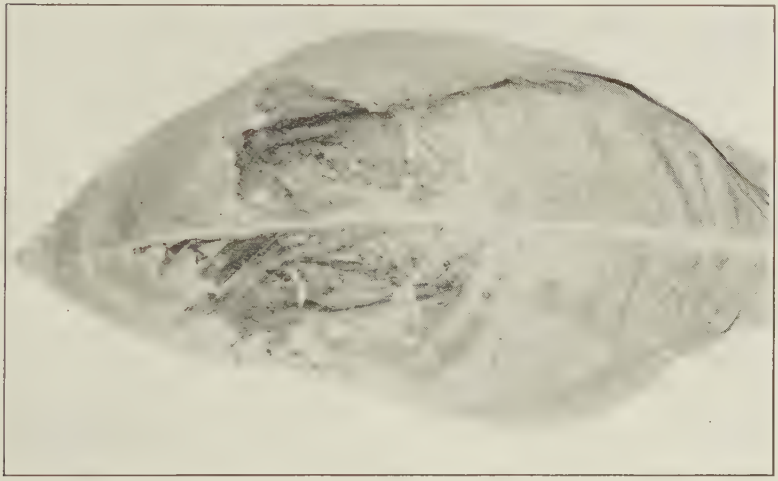


Figure 16. Mosaic burning. This type of injury often develops on one or two leaves of a plant recently infected with tobacco mosaic. Few tobacco growers recognize this as a symptom of mosaic because at the time these symptoms appear the mosaic symptoms may not be in evidence, especially in topped tobacco.

Certain weeds (horsenettle and groundcherry) become infected and carry the virus from year to year. But these appear to be minor carriers of the mosaic virus as compared with man. The disease is spread slowly from the weeds to tobacco, perhaps by insects, during the summer; hence it is practically impossible to completely prevent its occurrence in fields where infected weeds are prevalent. To remove the weed hosts of mosaic in and about a tobacco field any one year may not be practicable but an aggressive campaign against these weeds may in time prove valuable. These weeds are potential

hosts not only for tobacco mosaic, but for other viruses which affect vegetables, as cucumbers, tomatoes, and potatoes. If a tobacco bed is made in an area where horsnettles and ground-cherries infected with mosaic are abundant it is possible while weeding the bed to spread the disease from these weeds to an occasional tobacco plant. If this occurs, mosaic may be abundant in the field later on. While the problem of plant infection from weeds has not been studied it is probably best to make it a rule never to remove either of these weeds from the bed and never to touch them while pulling plants. Infected and healthy plants may grow side by side for weeks, without the disease spreading, if the plants are not handled.

Some evidence indicates that field infection may result from chopped tobacco stalks, known to carry the mosaic virus, applied to the field at the last disking before setting. Overwintered tobacco roots, of affected plants, retain some of the virus; but thus far no greater difficulty seems to have been encountered in preventing mosaic in plots on the Experiment Station farm set to tobacco each year, than in plots set to tobacco at less frequent intervals. It therefore seems safe to grow tobacco two or more years in succession without fear of extensive infection if the proper precautions to prevent infection from other sources are taken. Tobacco stalks, unless they come from a field known to be relatively free from mosaic, probably should not be used as a fertilizer for tobacco.

Plants inoculated with the disease at setting time make slower growth and may be much distorted and produce leaf of low quality. Late infection may cause mosaic burning in either White Burley or dark tobacco, and usually impairs the quality of the leaf. Patterns which are present in green tobacco are often still visible in the cured leaf (figure 17).

Prevention. Control of mosaic under Kentucky conditions, sufficiently effective for practical purposes, appears quite simple. Exclusion from the plant bed of all tobacco trash of previous year's crops, such as ground tobacco stalks and trash used as fertilizer and complete abstinence from the use of natural leaf tobacco during the weeding and setting season by those who

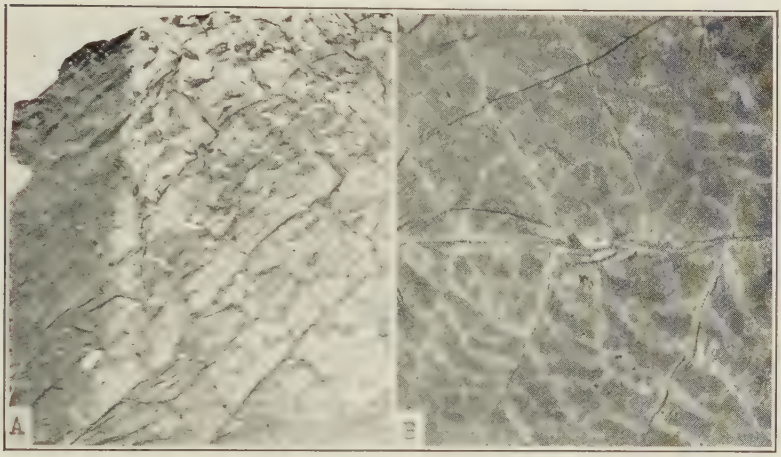


Figure 17. A. Tobacco mosaic patterns in a cured leaf of dark fired tobacco. The portion with patterns was taken with transmitted light and the remainder with reflected light. Leaf for photographing furnished by J. F. Freeman and Russell Hunt. B. A portion of a cured leaf of White Burley tobacco showing mosaic patterns with reflected light.

handle the plants, usually gives control. Before going to the plant bed all tobacco should be removed from the pockets and the hands should be thoroly washed with soap and water. Tests of commercial tobacco indicate that manufactured twists and scrap are probably always free from mosaic, and plugs rarely carry it. Cigarettes and tinned smoking tobacco, while they carry mosaic, have been proved safe to use. Therefore any of these types of tobacco may be safely substituted for the natural leaf tobacco during the plant-bed season. Horsenettles and groundcherries should not be handled while weeding or pulling plants. Mosaic may be introduced and spread while worming tobacco by hand. Therefore, it is preferable to control the tobacco horn-worm with poison dusts.* If these simple precautions are taken, damage from mosaic will be negligible, altho an occasional infected plant may be found.

Ringspot. Perhaps the most common and easily recognized of the virus diseases of tobacco, other than mosaic, is ringspot.

* See Kentucky Extension Circular 230 (Revised), page 19.

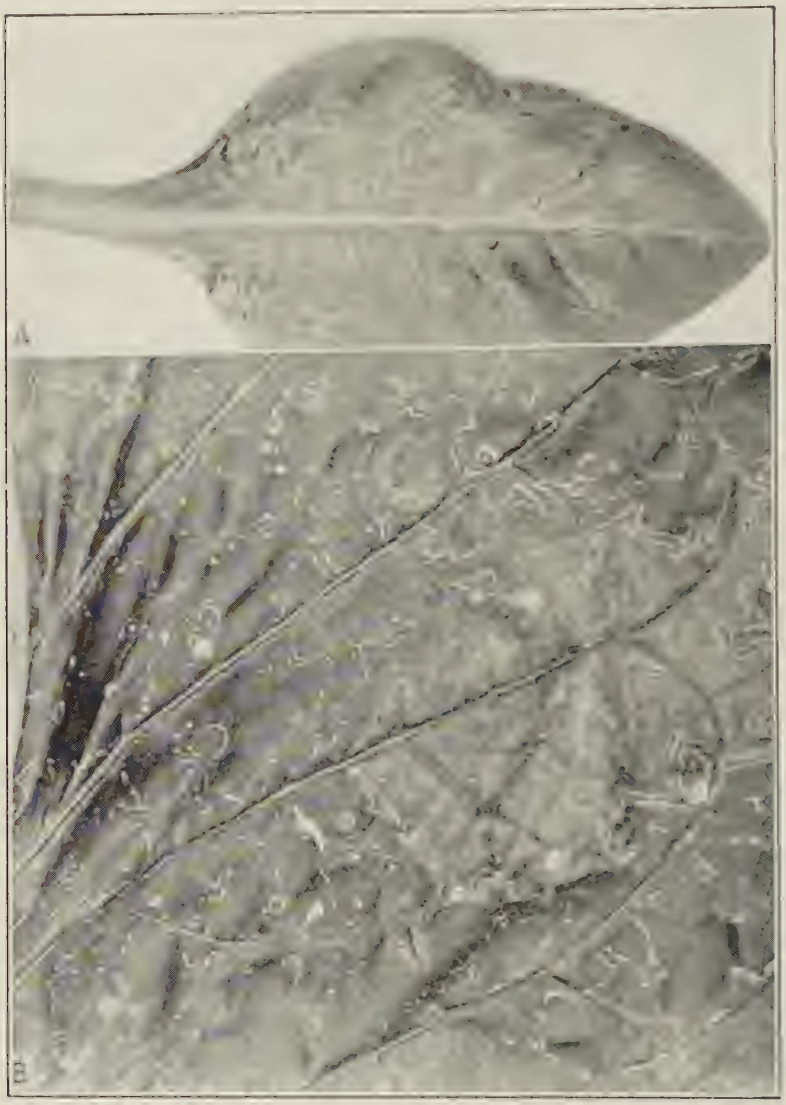


Figure 18. Ringspot of tobacco. A. A leaf from a plant in the bed evidently affected thru the seed. B. A leaf from the field. The dead lines, often in the form of rings, are characteristic of the disease.

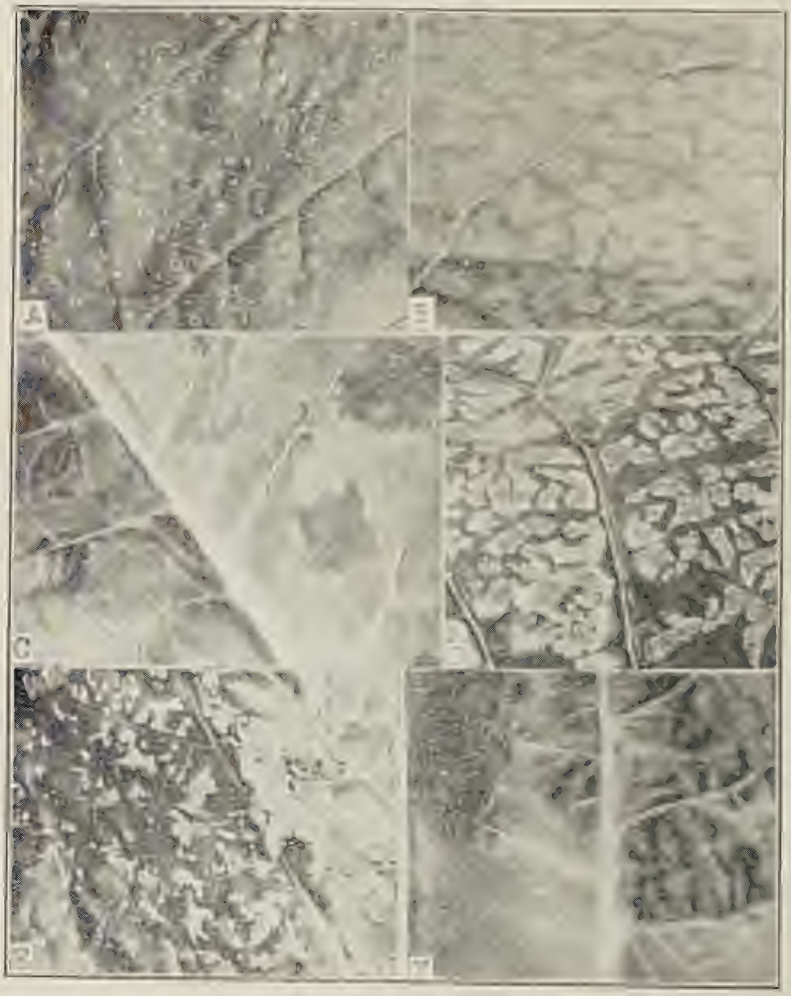
The name characterizes the disease quite well, as frequently dead rings occur, altho the symptoms vary greatly (figure 18). Sometimes the disease is destructive to individual plants, but is not very injurious except in occasional fields during certain years. It is questionable whether this virus disease will become severe enough to make preventive measures necessary. Ring-spot is found in nearly every tobacco crop examined. It has a wide host range. It may overwinter in horsenettle, ground-cherry, sweet clover, and probably in several other weeds. The virus does not remain alive in the cured leaf. It is carried in seed from affected plants and develops in an occasional seedling altho the ring symptoms may not appear. The first symptoms may appear on tobacco plants in the bed (figure 18, A) or on plants in the field almost as soon as growth commences following setting. The disease spreads gradually during the remainder of the season. With the exception of tobacco mosaic, it is the first virus disease to be recognizable in tobacco fields following setting. If measures for prevention become necessary in certain fields, they will probably center about the eradication of the weeds which prove to be the most potent sources of infection, and the use of seed from healthy plants. The disease is wide-spread in the State, and appears to be a common cause of mosaic in cucumbers. It sometimes affects potatoes also.

Streak. Rarely a tobacco field is seen in which large plants are practically destroyed by what appears to be a severe type of virus disease (figure 20). The disease might be called streak because of its similarity to the virus disease of tomatoes known as streak. The streaks consist of long, dead, depressed areas extending down the stalk but often originating on the under side of the midvein of a leaf. The leaves present when the plants become affected may yellow and die and the new leaves may be much distorted and peppered with small brown spots. A similar disease has been produced on half-grown White Burley tobacco plants by inoculating them with tomato tissue from plants which had a severe form of virus disease.

Speck-spot. A white or light brown specking of tobacco is frequently seen. It appears to be the result of virus infection.

It has been found associated with several of the tobacco virus diseases but has not been observed on plants free from infection (figure 19, A).

Other virus diseases. There are several other viruses which



Figur 19. Virus diseases of tobacco. A. Speck spot; B. Vein-banding; C. A mosaic which can be transferred to cucumber but which differs from the typical cucumber mosaic; D. Yellow tobacco mosaic; E. Coarse etch; F. Typical cucumber mosaic.

affect tobacco in the field but which are usually not very injurious. Several viruses, similar in nature to the cucumber mosaic virus, affect tobacco (figure 19, C, F). There are three viruses, differing in degree of severity, called the etch viruses, which affect tobacco. The veinbanding virus, commonly present in mosaic potato plants, attacks tobacco (figure 19, B). These and some other virus diseases of tobacco appear to occur most frequently in potato-growing areas. Experimental evidence indicates that several of them (veinbanding, etch and typical cucumber mosaic) may be carried from generation to generation in potatoes. While these diseases may affect a high percentage of plants in areas where potatoes are regularly grown they do not seem to cause enough injury to be observable in the cured tobacco.

STALK DISEASES

Fusarium Wilt. Wilt has been observed or reported a few times in Kentucky, but the disease does not seem to be serious

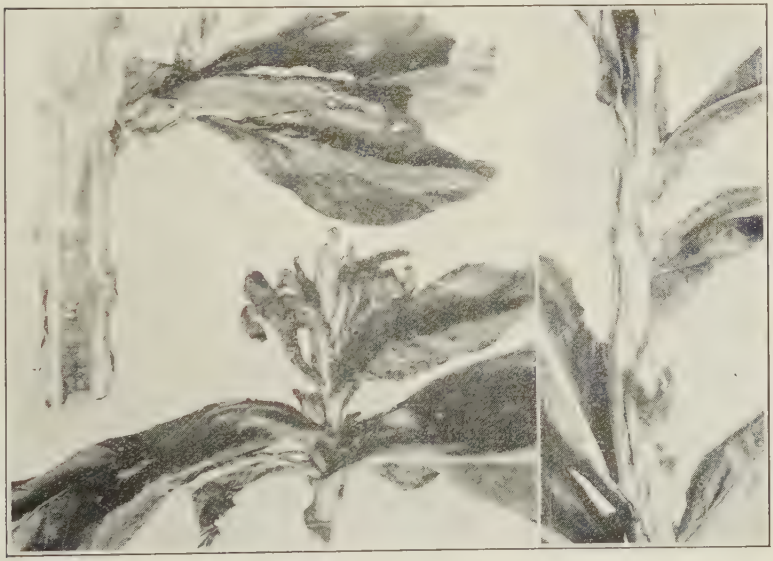


Figure 20. Streak of tobacco. This disease, while not prevalent, is very destructive to tobacco when it occurs. The concentric patterns in the pith are an unusual symptom of a virus disease.

and probably will not become so. Affected plants are usually scattered in the field, but instances have been seen where all the plants over a small area were destroyed. The disease is worse in sandy soil. If present in one crop it is likely to recur in the next crop set in the same field. It is more prevalent in White Burley than in dark tobacco but has been seen in the latter. The fungus enters a single root and spreads from it up the side of the plant causing the leaves on that side to turn yellow, wilt, and die. The rest of the plant may remain fairly normal altho bent toward the diseased side. If the stem of an affected plant is cut across, the veins on the wilted side will be found to be discolored. While the disease might appear to be a potential menace, it is probably not. It already seems to be widespread in the State, affecting most of the infected plants in such a mild way as to cause little injury. During the cool season of 1927 several fields of White Burley were observed in which a number of plants showed definite signs of wilt late in the season. A close inspection of surrounding plants indicated that probably all were affected, but not sufficiently to cause damage. The upper leaves had a peculiar yellowing characteristic of the disease, and cross sections of the petioles and stems showed a mild discoloration of the vascular tissue characteristic of wilt.

Prevention. It is best not to plant tobacco in fields where wilt has previously caused extensive injury. Fields where only an occasional plant was affected may be planted again without fear of extensive damage.

Lightning Injury. Lightning frequently strikes in a tobacco patch and when the plants are young it may cause their death in a circle sometimes as much as fifty feet in diameter. The plants in the center may be killed to the ground line, the roots being uninjured. The plants on the border of the affected area show little injury. The whole area has the appearance of a spot in which a disease is spreading very rapidly from a center and for this reason often causes alarm when first discovered. When lightning strikes in a patch of topped tobacco the stalk of an occasional plant may be killed and the tissues torn from between the secondary veins of the basal third of the leaves (figure 21).

Figure 21. A leaf from a topped plant of Burley tobacco struck by lightning. All the leaves on this and on two other plants in a large affected area were injured in this way and the stalks of these plants were instantly killed. This type of injury is comparatively rare but appears to result where the heavier bolts strike.

Plants showing all degrees of injury may be irregularly scattered over the area. The injuries are quite characteristic. The large leaf veins and the stalk are most subject to injury. The affected portions of the veins turn black and shrink giving the blade a pleated or gathered appearance (figure 22, B, C). The stalk may have sunken, dark-colored, areas on it or if completely killed may shrivel and become hard and leathery (figure 22, A). It is a peculiar fact that the stalk and midveins may be shriveled and dead and the leaves go on living normally for days, apparently because the root is unaffected and the water channels of the stalk remain open even tho dead. If a stalk is split open after it has dried somewhat the pith will be found to be separated into disks, giving a peculiar ladder-like effect (figure 22, A).

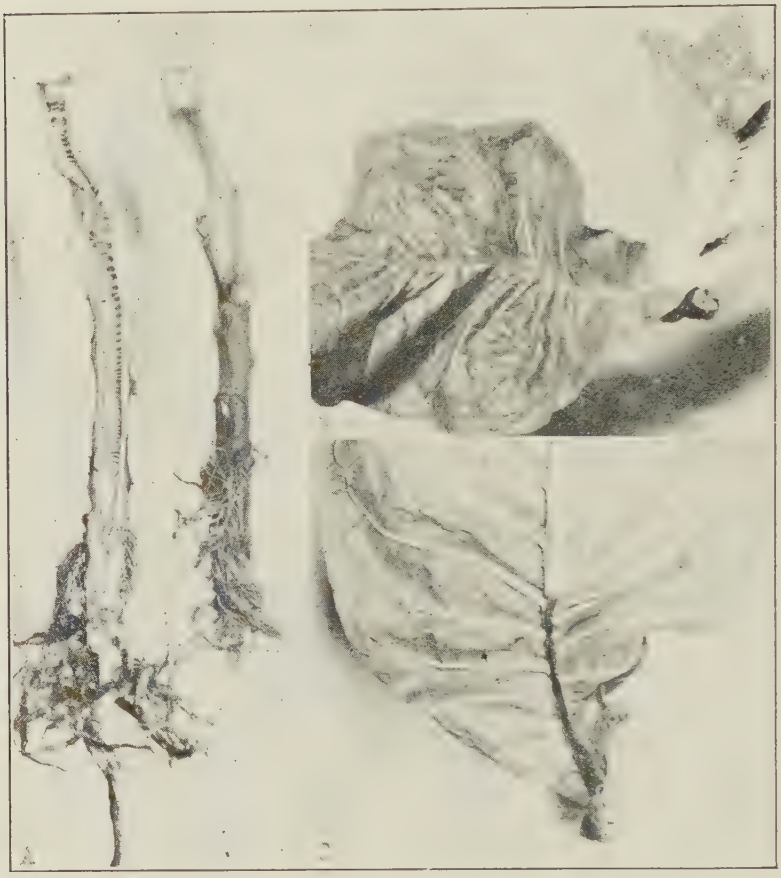


Figure 22. Lightning injury to tobacco. A. The shrunken stalk and separation of the pith into disks give a ready means of identifying lightning injury. B. The midveins of the bud leaves have been partly killed but in the large leaf the midvein is completely killed, giving the "gathered" effect. C. The lower portion of the midvein has been killed. The death of the midvein does not destroy the leaf which it supplies.

Sore-shin. Tobacco plants are sometimes affected with a disease causing blackening of one side or of the entire stem near the ground (figure 23). It may spread up the stalk some distance, causing the lower leaves to droop, finally killing the plant. The disease is somewhat similar in appearance to black shank which occurs farther south. Sore-shin has not been

studied in Kentucky and aside from its occasional appearance in tobacco fields, little is known about it. It is not likely to become a serious factor in tobacco production, as present cultural practices seem to hold it in check.

Figure 23. Sore-shin of White Burley tobacco. The base of the plant is blackened. The cause of the disease is not known.

Stalk-rot or Hollow Stalk. During wet seasons a rot of the pith of tobacco stalks is not uncommon. Infection is reported to occur thru wounds before topping or thru the wound left by breaking out the top. It spreads rapidly in the plant, causing a soft-rot of the pith and stem tissue (figure 24). The disease is caused by the same group of bacteria which causes bacterial

Figure 24. Stalk-rot or Hollow Stalk produced by inoculation with bacteria from a plant affected by black-leg in the bed.

soft-rot of vegetables and black-leg of tobacco in the plant bed. No means of prevention is known and because of the comparative rarity of the disease, it would hardly pay to take preventive measure against its possible appearance, even if such measures were known.

HOUSEBURN

Poor curing of the tobacco crop is the cause of immense losses to tobacco growers year after year. The injury to tobacco known as houseburn is probably the greatest single factor in this loss.

Houseburn is the result of the growth of fungi and bacteria on and in the dead leaves during periods of high relative humidity when the leaves become moist. It does not occur during the yellowing period except in parts of the leaf which have been killed. The organisms are not active at low tempera-

tures so that houseburn does not occur in cold weather. The ideal conditions for houseburn are temperatures between 60° and 100° F. and a relative humidity above 90 percent which checks the evaporation from the leaf and causes it to become soggy. Suckers left on the plant tend to induce houseburn in the leaves in contact with them.

In order to know how houseburn may be prevented several essential points in the curing of tobacco should be understood.* These are as follows:

1. Tobacco should be cut when it is properly ripened; that is, when there has been an accumulation of food material in the leaves principally in the form of starch. This replaces part of the green coloring matter, leaving a lighter green, flecked appearance. Ripe tobacco leaves are brittle because of the accumulation of starch, and snap when folded between the fingers.

2. Curing is a life process during which the green coloring matter breaks down and the leaf becomes lemon yellow. The starch is used in the process and other contents of the leaf are changed. Curing and yellowing are accelerated by rather rapid wilting and retarded when the leaf is turgid or full of water. Besides the loss of water in drying, the leaf loses about 12 to 20 percent of its weight from the use of starch, during the yellowing process. A further loss is caused by the passage of materials from the leaf into the stalk. The presence of suckers on the stalk during curing increases the loss of leaf weight in the attempt of the plant to keep the suckers alive. Drying and death of the plant are accelerated by splitting the stalk. It is therefore likely that splitting the stalk in harvesting tends to increase the weight of the leaf, as compared with spearing. The death of portions of the leaf from bruising, frost, too rapid drying, or other cause prevents them from curing, and produces green patches in the cured leaves.

3. Following yellowing the leaf quickly dies, altho the stalk remains alive for a longer time. Death of the lower leaves

* This discussion is largely condensed from the publications on curing tobacco by W. W. Garner of the Bureau of Plant Industry, Washington. For a more extensive discussion of tobacco curing see United States Department of Agriculture Farmers Bulletin 523.

naturally occurs first and death of the edges of the leaves precedes that of the remainder. When yellowing is completed and the tissues are dying the remainder of the curing process is primarily one of slowly drying the leaf.

4. Browning or reddening which follows the death of the leaf is due to oxidation of substances in the leaf. It proceeds best at a relatively high humidity and more rapidly at higher temperature. Each time the tobacco becomes damp or "comes in high case", the depth of color increases. The chief danger in air curing is that this process will go too far because of excess moisture, causing the leaf to cure too dark.

5. Leaf activity nearly ceases at 40° F., but becomes more active as the temperature is raised. At 125° F. the cells of the leaf are rapidly killed, while at 115° F. longer exposures will kill the leaf. The best temperatures for the first stage of curing or the yellowing process are between 60° and 100° F. A barn to which artificial heat is not applied rarely becomes too hot but it may readily become too cold for proper curing.

6. Relative humidity or the percentage of saturation of the air at a given temperature is an important factor in curing. During yellowing a relative humidity of 85 percent is desirable. If it goes to 90 percent or above, microorganisms may develop, on dead portions of the leaves, resulting in houseburn. If it goes much lower than 85 percent the tobacco may dry too rapidly. At ordinary temperatures, a rise of 20° F. changes the relative humidity of a saturated atmosphere to about 50 percent. In other words, the water-holding capacity of the air is doubled by a rise of 20° F. A barn full of tobacco at a moderate temperature may become wet if a rainy period sets in with rising temperature. This is because vapor from the saturated atmosphere condenses on the cooler leaves.

7. Heated air rises and will pass out of the ventilators at the top of the house, carrying the excess moisture. Air of high humidity is lighter than drier air and will pass out of the top ventilators. In cold weather the curing processes stop and if drying continues the leaf simply dries out.

With these facts in mind the principles involved in preventing houseburn and too dark a color in the cured leaf are more readily understood. The tobacco should be wilted as much as is practicable before being put into the house. It should then be kept at temperatures between 60° and 100° F. and at a relative humidity of about 85 percent. The relative humidity may be determined by the use of a wet and dry bulb thermometer together with the necessary tables. Such a pair of thermometers, properly mounted, is called a psychrometer. In dry weather the relative humidity may be maintained by keeping the barn tightly closed during the day and open at night. The barn, of course, should be capable of being closed tight. In wet weather when the air is saturated, relative humidity can only be regulated by heat and proper ventilation. In Burley and air-cured dark tobacco barns this may be done with coke fires, either on the floor (with gas coke) or in specially constructed burners. In the fire-cured dark-tobacco barns it is commonly done with wood fires. When fires are used the upper ventilators should be opened sufficiently to carry off the moisture-laden air and the lower ventilators opened sufficiently to allow the cooler air to enter. It should be remembered that heating the air increases its water-holding capacity. When yellowing has been completed and the leaves are dead the relative humidity should be decreased first to about 80 percent and later to 65 to 70 percent and maintained at that point until the stalks are dry. At this point curing is complete. After the tobacco is cured it should be bulked down, as soon as it can be brought sufficiently into case for handling, and stripped and graded as soon as possible. It should be remembered that each time tobacco becomes damp either during the second period of curing or after curing, the color is darkened and there is danger of houseburn.

In curing fire-cured tobacco the same principles apply. The tobacco should hang in the barn for three or four days to bring about yellowing. This may be hastened about the fourth day by slow fires which raise the temperature to about 90° to 95° F. This temperature is maintained for about 24 hours. As soon as the leaf is yellowed the temperature may be increased gradually

until 125° to 130° F. is reached. This is maintained until the leaf is dry. If the fires die out the leaf again becomes pliable from the flow of sap from the stem and stalk and the fires should be started again. If the tobacco is allowed to hang in the barn for any considerable period after curing is completed, slow fires should be started during periods of wet weather to prevent houseburn and to prevent the tobacco from becoming too dark.